WO 83/01044 : BRAKE SYSTEM FOR A VEHICLE

The invention relates to a brake system for a vehicle having a disk brake, which has a brake disk rotating with a vehicle wheel, a brake housing connected to a non-rotating vehicle part and a brake shoe, whereby depressing a brake pedal a pressing force is indirectly produced between the brake shoe and brake disk.

The presently used, conventional brake systems for motor vehicles operate with hydraulically or pneumatically produced pressing forces acting on the brake shoes.

Pneumatic or hydraulic systems of this type are expensive and complicated with regards to the number and construction of their components and with regards to the necessary line system. This more particularly occurs in the implementation of several, independent brake circuits, such as are nowadays required for safety reasons in motor vehicles. An electrical brake operation would also be desirable with regards to electrically operating additional and monitoring devices for brake systems in motor vehicles, such as an antilocking device or brake lining wear monitoring means.

The use of per se known electromagnetic brakes in vehicles, particularly motor vehicles, has hitherto been prevented in that remanence occurs which, even after releasing the brake, i.e. after disconnecting the coil current, produces a residual pressing force due to the remanent magnetism. In order to overcome this pressing force caused by remanence, it is admittedly known to provide a spring, which moves apart from one another the friction elements cooperating during braking, whilst overcoming the pressing force caused by remanence (French patent 1 309 724). However, this known construction does not permit the sensitive metering of the braking action more particularly needed in motor vehicles.

The problem of the invention is to provide a simply constructed brake system, which permits brake operation with little effort and expenditure whilst using electric auxiliary energy.

In order to solve this problem, in a brake system of the aforementioned type, the invention provides for the pressing force being electromagnetically produced whilst indirectly or directly adjusting the braking moment.

In a preferred embodiment of the invention, action takes place on an electric displacement or force sensor by means of the brake pedal and as a result the power supply to the coil of an electromagnet is modified as a function of the pedal position, the braking moment of the brake being adjusted by an adjusting means, whose inputs form the output signals of an electric

displacement or force sensor and a device determining or simulating the braking moment or a quantity linearly variable therewith. The brake disk can be formed by an armature disk and the brake housing by a stator housing of an adjustable electromagnetic brake.

Surprisingly the brake system according to the invention has the desired, precise meterability. This results from the adjusting of the braking moment, which eliminates the described remanence problem without using a spring, in that on releasing the brake the remanence is adjusted to zero by "counteradjusting", i.e. supplying the electromagnet with a current acting in opposition to the brake operation current. Advantageously the braking moment is controlled by adjusting the electromagnetic flux, which would be proportional to the braking moment without remanence.

The electromagnetic flux can easily be measured on each vehicle wheel, preferably using a Hall generator. If on releasing the brake a flux persists as a result of the remanence in the material of one or more brake parts, then through the adjusting means a current is fed into the coil of the electromagnet and produces a counterflux compensating the "remanence flux". This takes place at such a speed that on releasing the brake the pressing force disappears as in the case of conventional hydraulic or pneumatic brakes.

According to an advantageous development of the invention, the adjusting or controlling means forms part of an electromagnetic signal processing unit which, apart from the components for the braking moment-dependent adjustment, contains further electrical components, such as those of an electric brake servo and/or the central processing unit of an antilocking device and/or a brake shoe wear indication. Instead of measuring and adjusting the electromagnetic flux (or directly the braking moment), on knowing the brake behaviour the latter can also be simulated by means of a simulation computer and the signals simulated as a function of the particular brake state can be returned to the adjusting means, so that a so-called adaptive adjustment is brought about.

The brake is appropriately constructed as a solid disk brake with one or more friction pairs, particularly in the form of brake laminations. In order to increase safety, a permanent magnet constantly acting in the operating sense is provided and opposes the electromagnet in the brake releasing sense. If a power failure occurs, the brake is automatically applied. This safety feature which is easy to implement in the invention cannot or can only be implemented with considerable effort and expenditure in a hydraulic or pneumatic brake.

In summarizing, the brake system according to the invention leads to the

following main advantages:

- All the connections between the brake pedal and the brakes are electrically conducting cables, which considerable reduces installation costs for the brake system.

- For increasing operational reliability, the subassemblies of the brake system can more easily be given a redundant construction than in pneumatic or hydraulic brake systems and fewer components are needed.

- As electric signals already exist, if a component fails or the brake shoes become worn, without the provision of additional sensors a fault indication on the dashboard is possible.

- Additional electric devices, such as antilocking devices, brake servos, brake shoe wear indicators, etc. can be installed and adapted less expensively than in hydraulic or pneumatic brake systems.

- Additional hydraulic or pneumatic devices are rendered superfluous.

- The brake system according to the invention is suitable for vehicles of all types, i.e. for rail vehicles and aircraft in addition to road vehicles.

The invention is described hereinafter relative to embodiments and the attached diagrammatic drawings, wherein show:

Fig. 1 A diagram of an electromagnetic brake according to the invention for a motor vehicle, only the essential brake parts being represented.

Figs. 2 and 3 Block circuit diagrams of alternative control circuits for the brake of fig. 1.

Fig. 4 A circuit diagram for a brake system with electromagnetic brakes according to fig. 1.

Fig. 5 An axial section through an electromagnetic brake according to the invention.

The electromagnetic brake shown in fig. 1 has a brake or armature disk 1, which is connected in rotary, but axially displaceable manner with the associated wheel of a not shown motor vehicle.

Axially adjacent to the armature disk 1 is provided a stator housing 3 connected to a non-rotating vehicle component, such as a not shown wheel

bearing housing. The stator housing 3 houses the annular electromagnetic coil 2 and adjacent thereto an annular brake shoe 4 made from brake lining material.

A current flowing in the coil 2 produces a magnetic field 5, which produces a force of attraction between the armature disk 1 and stator housing 3 and therefore a pressing of said disk 1 against the brake lining 4. The magnetic flux 5 is measured by means of a Hall generator 6 located on the stator housing 3 and converted into an electric signal 7. In place of the Hall generator it is also possible to provide a not shown braking moment sensor, which measures, in place of the magnetic flux, the braking moment proportional thereto. It is clear that in place of the described construction the armature disk can also be constructed in axially stationary manner, whereas the stator housing can be axially movable.

A change to the coil current gives rise to a proportional change to the magnetic flux 5 and therefore the pressing force. Since as a rule the material of the brake parts, particularly the brake disk, has a remanence, i.e. a temporary retention of the magnetic action after disconnecting the coil current, the remanence in the form of a persisting operating force must be compensated and this is carried out using the adjusting or control circuits according to figs. 2 or 3.

In the case of the control circuit according to fig. 2, a desired value signal 8 for the braking moment on the brake and which is derived from the brake pedal position is compared as regards quantity and direction with the output signal 7 of the Hall generator 6. The resulting control difference 9 is amplified in the adjusting or control means 10 and supplied by means of a final power stage (amplifier) 16, allowing a current flow in both directions, to the brake 1, 3.

In the alternative according to fig. 3 in place of a sensor 6 for the magnetic flux (or for the braking moment) a simulation computer 6' is provided, which simulates the known brake behaviour. The output signal 7 produced by the simulation computer is once again subject to a desired-actual value comparison and the deviation formed is fed into the control means 10 which, in the same way as with the control circuit according to fig. 2, acts by means of an amplifier 16 on the brake 1, 2, 3.

An example for the construction of a brake system for a motor vehicle with four solid disk brakes according to fig. 1, namely in each case a disk brake on each vehicle wheel, is shown in fig. 4. By means of a rod 12, a brake pedal 13 acts on two angle, displacement or force sensors 14, which supply electric control signals identical to the magnitude of the foot force applied to the brake pedal. These control signals 8 are supplied by means of a

signal processing unit 100 containing the adjusting means 10 according to figs. 2 and 3, which can also contain additional components, such as the central processing unit of an antilocking device. Inputs for said central processing unit are made available in known manner by speed indicators 18 associated with each wheel. The signal processing unit also receives the output signals 7 from the Hall generator 6 in the form of inputs. To each wheel brake belongs an amplifier 16, which is controlled with an output signal 17 formed in the signal processing unit 100. The amplifier 16 supplies an electric output signal 19 to the relevant coil 2 of the electromagnetic brake. This output signal is such that it compensates the remanence caused by the brake materials.

Fig. 5 shows an actual brake system, where functionally coinciding parts are given the same reference numerals as in figs. 1 to 4.

A vehicle wheel 30, in the present case a non-driven front wheel of a road vehicle, has a wheel dish 31, in whose interior is placed a solid disk brake 32. To said vehicle wheel 30 belongs a wheel disk 29, which is connected by means of a nut rim with nuts 33 in non-rotary, axially non-displaceable manner to the wheel dish 31 and which is mounted in rotary manner conventionally on a stub axle 36 by means of wheel bearings 34, 35. The wheel disk 29 terminates in an axial flange 37 having inner grooves 38 in which engage outer grooves of brake laminations 39, which are non-rotary, but axially displaceable in the inner grooves 38. On a collar 40 of the stub axle 36 is fixedly mounted the hub 41 of a stator housing 3 and said hub is provided on its outside with keyways 42. With said keyways 42 cooperate inner keyways on an axial inner flange of a brake disk 1, which is consequently placed in non-rotary, but axially displaceable manner on the hub 41 of the stator housing 3. On its outer circumference the stator housing 3 has axial keyways 43 with which cooperate the inner keyways of the brake laminations 44, which are received between the brake laminations 39 or faces 46, 47, directed towards one another, of the wheel disk 29 and brake disk 1.

As in the preceding drawings, reference numeral 6 designates a Hall generator fixed to the stator housing 3 for measuring the magnetic flux and converting it into an output voltage corresponding thereto.

If a current is supplied to the coil 2, e.g. by the signal processing unit 100, a magnetic flux is produced applying the brake disk 1 on stator housing 3. Thus, in fig. 5, the brake disk 1 is moved to the left, so that it presses the brake laminations 39, 44 against one another and/or on the right-hand face of the wheel disk 29 and consequently produces a braking action, which can be precisely metered as a result of the arrangement described. Remanence caused by the brake disk material, the stator housing material or the wheel disk 29 is compensated by adjusting the magnetic flux, so that on

releasing the brake, the braking action is immediately cancelled out in the same way as in the case of a hydraulic or pneumatic brake. In the manner described hereinbefore this can take place by producing a magnetic flux opposing the remanence and which forces the brake disk 1 away from the brake laminations. The stator housing 3 can also receive a permanent magnet or can itself be constructed as a permanent magnet. Alternatively the brake disk can be constructed as a permanent magnet with a flux direction such that it applies the brake disk 1 to the wheel disk 29. In this case the current flow through the coil 2 produces an action opposing the action of the permanent magnet and at least in normal travel eliminates the same. For braking purposes the coil current is reduced. The permanent magnet force then exceeds the electromagnet force, so that the brake is applied. This admittedly presupposes a continuous current flow through the coil 2 when the brake is not applied, but as a result increases safety in that the brake is always applied if the power supply fails.

In place of a solid disk brake it is obviously also possible to adopt a construction in the form of a partial liner disk brake. However, the solid disk brake has advantages when using the above-described electromagnetic operation in connection with the standard annular arrangement of an electromagnetic coil with the associated parts. Use can be made of commercial brake parts. Heating problems can be controlled, because the surface loading is much lower than with partial liner disk brakes and there are adequate radiation surfaces on the wheel disk or brake disk for heat dissipation purposes and this can be increased by a ribbing.

CLAIMS

1. Brake system for a vehicle with a disk brake, which has a brake disk rotating with a vehicle wheel, a brake housing connected to a non-rotating vehicle part and a brake shoe, where as a result of the depressing of a brake pedal a pressing force is indirectly produced between the brake shoe and brake disk, characterized in that the pressing force is electromagnetically produced with a direct or indirect adjustment of the braking moment.

2. Brake system according to claim 1, characterized in that by means of the brake pedal an electric displacement or force sensor (14) is operated and modifies the current supply to the coil (2) of an electromagnet as a function of the pedal position, the braking moment of the brake being adjusted by an adjusting means (10), whose inputs form the output signals of an electric displacement or force sensor (14) and a device (6, 6') determining or simulating the braking moment or a quantity linearly variable therewith.

3. Brake system according to claim 1 or 2, characterized in that the brake disk is formed by an armature disk (1) and the brake housing by a stator housing (3) of the electromagnet.

4. Brake system according to one of the claims 1 to 3, characterized in that the braking moment is indirectly adjusted by adjusting the magnetic flux.

5. Brake system according to claim 3 and 4, characterized in that with each vehicle wheel is associated a sensor (6), which measures the electromagnetic flux in the brake parts.

6. Brake system according to claim 5, characterized in that each sensor (6) is formed by a Hall generator.

7. Brake system according to one of the claims 1 to 6, characterized in that the adjusting means forms part of an electronic signal processing unit (100) which, apart from the components for the braking moment-dependent adjustment, contains further electrical components, such as those of an electric brake servo and/or the central processing unit of an antilocking device and/or a brake lining wear indication.

8. Brake system according to claim 7, characterized in that an amplifier (16) is placed on each vehicle wheel between the signal processing unit (100) and the individual electromagnets (1, 2, 3).

9. Brake system according to one of the claims 1 to 3, characterized in that an adjusting means (10) provided for adjusting the braking moment receives as the input a return signal made available by a simulation computer (6').

10. Brake system according to one of the claims 1 to 9, characterized in that the brake is constructed as a solid disk brake with one or more friction pairs (39, 44), particularly in the form of brake laminations.

11. Brake system according to one of the claims 2 to 10, characterized in that a permanent magnet is provided constantly urging the brake in the operating sense and which opposes the electromagnet in the brake release sense.